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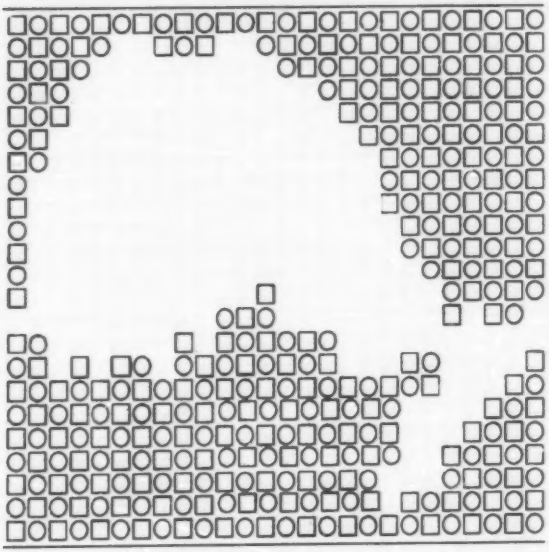
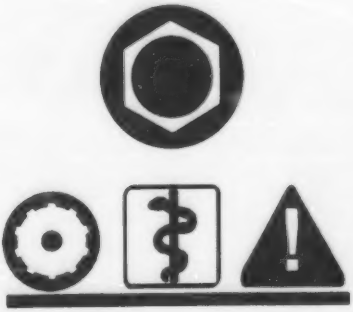
Designated Substances in the Workplace: A Guide to the Benzene Regulation





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Designated Substances in the Workplace: A Guide to the Benzene Regulation

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Introduction

The guide has been prepared to help employers, workers, members of joint health and safety committees, supervisors and occupational health personnel meet the requirements of the designated substance regulation respecting benzene in the workplace and to understand the responsibilities this regulation places on all participants in the workplace health and safety system.

The advice in this guide is an interpretation of the *Occupational Health and Safety Act* (the Act) and regulations by officials of the Operations Division.

The advice does not have binding effect but is intended to provide general answers to possible questions asked in the context of a specific situation. It is being used by staff of the ministry to assist in the administration of the benzene regulation.

Questions of construction and application will find their ultimate answer given by the courts where a contest ensues as to construction or application of a legislative provision.

The Operations Division of the Ministry of Labour is responsible for administering the Act. The Regulation respecting Benzene, Ontario Regulation 732/84 was filed with the Registrar of Regulations on November 16, 1984. The provisions relating to the assessment came into force on the date of filing; those relating to control measures came into force on February 14, 1985. The regulation was subsequently amended, most recently in June, 2000,

and is now known as Regulation 839, as amended by O. Reg. 511/92 and O. Reg. 387/00.

This guide is intended as a supplement to the booklet entitled *Designated Substances in the Workplace: A General Guide to the Regulations* to help employers meet the requirements of the benzene regulation. It reviews the health effects of benzene, its uses and the forms of workplace exposure. In addition, it provides information on the application of the regulation, allowable exposure levels, the assessment and control program and medical surveillance.

It is important that both this guide and the general guide to the regulations, referred to above, be consulted.

For further information on any aspect of the benzene regulation, you should contact the appropriate Ministry of Labour field office. Appendix 2 lists the addresses and telephone numbers of the ministry field offices.

1. The Hazards of Benzene in the Workplace

What Is Benzene, Where Is It Found and How Is It Used?

Benzene is an aromatic organic hydrocarbon. Its molecular structure is six carbon atoms and six hydrogen atoms arranged in a symmetrical ring structure. Benzene is a clear colourless liquid with an odour characteristic of aromatic hydrocarbon substances. It is highly flammable and volatile, giving off flammable vapours that are almost three times heavier than air. Benzene may exist as a liquid or vapour at normal temperatures and pressures and it will freeze to a solid at temperatures below 5.5°C.

Benzene occurs naturally in the environment. It exists in the atmosphere mainly as a result of automobile exhaust and cigarette smoke. Therefore, everyone is exposed to benzene to some degree. Occupationally-exposed workers are likely to have a much higher intake of benzene than the population at large.

Historically, benzene has been produced as a by-product of coal gasification and metallurgical coke production in steel making. The light oil product from such processes contains benzene, toluene and xylene, and these components are separated by distillation. Today, most benzene is produced from the refining of petroleum.

Benzene is used in the production of styrene and a wide range of synthetic rubbers, plastics and resins. Benzene is also used in the synthesis of phenols, alkyl benzene detergent base materials, and cyclohexane and other solvents.

Benzene has application as a solvent in synthetic rubber manufacture and processing and in paints, varnishes, stains, adhesives and sealants. Use of benzene in tire and other rubber

goods manufacturing and as a solvent and component of paints and adhesives has declined considerably as a result of concerns about workplace exposure. Nevertheless, it is often present in trace quantities in petroleum and aromatic solvents, some of which have replaced benzene in many uses. Benzene is also a minor component (less than 2.5 per cent) of gasolines sold in Canada.

Why Is Benzene a Health Hazard?

In addition to the health hazard it presents due to its flammability and volatility, benzene, in common with many other toxic substances, may be harmful following a high dose received in a short period of time (acute exposure) or after long-term exposure to lower doses (chronic exposure). In this context, dose means the quantity of benzene absorbed into the body and is primarily a function of the concentration in the workplace air, the duration of exposure and the efficiency of the lungs in transferring benzene into the blood.

Acute exposure to benzene affects the central nervous system, with some irritation of the eyes, nose, throat and skin also occurring. Short-term exposures to concentrations of 250 to 500 ppm in air produce symptoms such as dizziness, confusion, headache and weakness. At higher concentrations, up to 3,000 ppm, euphoria and eventual unconsciousness will result from prolonged exposure. At massive concentrations, around 20,000 ppm or higher, respiratory collapse and death will occur within minutes.

Chronic exposure to benzene affects the blood forming system, particularly the bone marrow. Exposure may adversely affect red cells, white cells and platelets, reducing the number of one or all in the blood and/or changing their structure. Red cells carry oxygen and nutrients to the body tissues, and a reduced red cell count is characterized as anemia. White blood cells contribute to the body's defence against disease, and a reduced white cell count adversely affects this defence mechanism. Platelets help blood to clot; excessive and uncontrolled bleeding may result when there is a shortage of these elements in the blood.

Benzene exposure may also cause the onset of leukemia (cancerous blood cells). The presence of leukemic cells in the blood may be preceded by some of the blood disorders previously described or may occur after an apparent recovery from these disorders. Leukemia may also occur without any prior signs of blood disorder.

These chronic effects may be alleviated by eliminating benzene exposure. The time required for recovery will depend upon the severity of the blood changes, and, in extreme cases, the recovery period may be several months. In very severe cases no recovery may occur and death may result.

In summary, benzene exposure induces blood and bone marrow toxicity. It has also been found to be clastogenic (causing chromosomal damage) in humans and mice, and has shown fetotoxic effects in mice and rats. It has been concluded that benzene exposure in the workplace has the potential to cause blood disorders, anemia, bone marrow diseases and leukemia among exposed workers.

How Is Benzene Absorbed Into the Body?

The predominant route of exposure to benzene for workers is the breathing (inhalation) of vapours and mists. Experiments on human volunteers indicate that about 50 per cent of inhaled benzene is absorbed into the body; however, 30 to 50 per cent of this absorbed benzene is eliminated in exhaled breath. These rates of absorption and elimination vary greatly from person to person.

Liquid benzene can be ingested by swallowing or absorbed through the skin. Because benzene is a powerful solvent, it will dissolve fat in the skin, and therefore, repeated skin contact can lead to dermatitis. Benzene will also produce a burning sensation and severe irritation on contact with the eyes.

Minor amounts of benzene may be ingested from food, drink, chewing gum or cigarettes that become contaminated when brought into the work area. Ingestion of benzene may also result from

eating or smoking when the hands or eating utensils are contaminated.

Rates of absorption and toxic effects of ingested benzene are believed to be similar to those of inhaled benzene, although no definitive information is available in this regard.

Similarly, the effects of the skin absorption of benzene are not well documented.

Absorbed benzene tends to migrate to fatty tissues and accumulate in bone marrow and the central nervous system.

What Are the Workplaces Where Benzene Exposure May Occur?

Benzene exposure may occur in workplaces where benzene itself is produced or used or where benzene-containing products are used and distributed.

Benzene is produced by major petroleum refiners and petrochemical producers in Ontario, who have facilities to synthesize and/or extract benzene from petroleum. Benzene is also produced as a component of light oil by-product from metallurgical coke production at the major integrated steel making operations in Ontario.

More than 80 per cent of the benzene produced in Ontario is used to make styrene. Benzene is also used as a solvent in the production of polybutadiene synthetic rubbers.

Other than in synthetic rubber manufacturing and limited laboratory applications, the use of benzene as a solvent is declining, but benzene is still present in trace concentrations in many of the solvents that have replaced it. The reclamation of solvents by distillation for re-use and the disposal and incineration of waste or surplus solvent materials and other organic industrial liquids are also work activities that can result in worker exposure to benzene.

Because benzene is a component of gasoline, workers in gasoline production and distribution have the potential for exposure.

Table 1 lists industries where benzene exposure is possible.

Table 1

Types of Industries With Potential for Benzene Exposure

- Petroleum refining
- Coke by-product/metallurgical coke production
- Styrene and synthetic rubber production
- Tire manufacturing
- Rubber goods manufacturing
- Adhesives and sealants manufacturing
- Petrochemical production
- Detergent alkylate production
- Paint manufacturing
- Gasoline distribution
- Footwear manufacturing
- Liquid organic industrial waste disposal
- Miscellaneous solvent usage in laboratories, furniture finishing/re-finishing, solvent reclamation, consumer products.

2. The Benzene Regulation

Who Is Covered by the Benzene Regulation?

With the exception of construction projects (explained below) and the delivery of gasoline by a pump into the fuel tanks of motor vehicles and boats or into portable containers, the regulation applies to every employer and worker at a workplace where benzene (or a product containing benzene) is likely to be inhaled, absorbed or contacted by a worker during its transportation or transfer or during its manufacture, processing, use, handling or storage. Table 2 summarizes the types of work with potential for exposure to benzene.

Workers involved in the bulk transfer, transportation and off-loading of gasoline remain subject to the regulation because of the potential for high benzene exposure among these workers. Similarly, workers involved in benzene production, coke oven by-products plants and styrene or polybutadiene rubber production are at risk of long-term exposure in excess of 1 ppm benzene, with some workers potentially exposed to concentrations greater than 5 ppm on an 8-hour time-weighted average (TWA) basis.

Industries involved in the use of benzene-containing solvents (paint manufacturers, adhesives formulation, rubber fabrication) usually present less potential for occupational exposure to benzene. Such solvents usually contain about 0.1 per cent benzene, and exposures have been shown generally to average less than 1 ppm over an 8-hour period.

Table 2

Type of Work With Potential Exposure to Benzene

A. Benzene Production:

- Coke oven by-product unit operations
- Light oil loading, off-loading and bulk storage transfers
- Petroleum refinery benzene production unit operations
- Benzene loading, off-loading and bulk storage transfers
- Benzene and light oil tank sampling, testing and analysis
- Maintenance and inspection of benzene and light oil production units, storage and handling facilities

B. Benzene Usage:

- Benzene transport, loading and off-loading
- Ethyl benzene production unit operations
- Styrene production unit operations
- Polybutadiene production unit operations
- Maintenance and inspection of ethyl benzene, styrene, polybutadiene production units, storage and handling facilities
- Leather work involving the use of benzene as a solvent
- Laboratory work involving benzene use as a solvent or reagent in laboratories

C. Indirect Usage – Use of Benzene-containing Products:

- Hydrocarbon solvents in paints and coatings, adhesives, rubber goods manufacturing and footwear manufacturing
- Solvent reclamation and recovery operations, loading, off-loading, storage and transfer of reclaimed solvents
- Liquid industrial waste disposal and liquid organic waste incineration
- Transfer, transport, off-loading of gasoline

Does the Regulation Apply to Construction Projects?

Subsection 3(3)(a) of the regulation specifically exempts an employer and the workers of an employer who is primarily engaged in the business of construction from the requirements of subsection 3(2) and sections 4 through 17 of the regulation.

If the construction project is located at a workplace to which the regulation applies, then the employer responsible for the workplace is required to comply with sections 4 and 5 of the regulation with respect to the workers on the project. Sections 4 and 5 set allowable exposure levels for airborne benzene and determine the conditions under which respirators may be used as a means of complying with these requirements.

Does the Regulation Apply to Gasoline Service Stations and Retail Outlets?

While the regulation does apply to gasoline bulk terminals and the transport and delivery of gasoline to service stations or other premises, it does not apply to the delivery of gasoline into the fuel tank of a motor vehicle, motor boat, or other water craft or into a portable container at a service station or other premises.

What Are the Allowable Airborne Benzene Concentrations?

The benzene regulation requires that workers' time-weighted average (TWA) exposure to benzene not exceed **1 part per million (ppm)** by volume or 3.2 milligrams per cubic metre (mg/m^3) of air. The maximum exposure shall not exceed **5 ppm** or 16 mg/m^3. (See sections 4(1) and (2) of the regulation.)

The time-weighted average exposure of a worker is calculated on the basis of cumulative weekly exposure (40 hours), and cumulative daily exposure (8 hours), as indicated in the Schedule appended to the regulation. Examples of such a calculation are given in Chapter 6 of *A General Guide to the Regulations*.

Employers must use engineering controls, work practices, and hygiene practices and facilities to achieve these exposure values. Only in emergencies or in cases where there are no practical or technically feasible alternatives are these allowable exposures to be achieved through the use of respirators worn by workers.

3. Assessing and Controlling Exposure to Benzene

The Assessment

Chapter 2 of *A General Guide to the Regulations* describes how to assess the extent to which workers are exposed to benzene. When you are carrying out this assessment, you must note all processes involving benzene and the manner in which benzene is likely to be released into the workplace. In addition to potential sources of airborne benzene, you should be alert to situations that may result in ingestion or skin absorption of benzene. Wherever benzene vapours or liquids are used, pay particular attention to work practices, hygiene practices and facilities.

Table 2 on page 9 presents a list of industrial processes or operations with a potential to expose workers to benzene. Work of this nature should be carefully assessed for benzene exposure.

Section 6 of the regulation places an obligation on employers to prepare a written assessment of the nature and potential extent of exposure of workers to benzene in the workplace. In many cases, whether or not an assessment is actually carried out will depend on whether the employer is aware of the potential for benzene exposure. It is therefore important to have available material safety data sheets (MSDS) on all chemicals, materials and solvents used in the workplace to determine whether benzene is present.

A written assessment report must be prepared and should include a summary of the information gathered and the analysis of these data. The report must state whether there is actual or potential exposure of workers to benzene and whether their health may be affected. The conclusion must indicate whether or not a control program is necessary.

More information on the conclusions that may be reached is outlined in Chapter 2 of *A General Guide to the Regulations*.

It may be necessary to include air sampling as part of the assessment for benzene. Direct reading instruments, including colorimetric indicator tubes, will often be adequate for determining the general degree of benzene exposure. Such instruments are, however, subject to a considerable degree of inaccuracy due to interference of other substances, inherent variability or insensitivity. Should an accurate determination of exposure be required, standard methods for workplace air sampling and analysis should be used. These would include methods published by agencies such as NIOSH (the U.S. National Institute for Occupational Safety and Health), OSHA (U.S. Occupational Safety and Health Administration), HSE (U.K. Health and Safety Executive), ASTM (American Society for Testing and Materials) and ISO (International Organization for Standardization).

The Control Program

Chapter 3 of *A General Guide to the Regulations* describes how to develop a written control program in consultation with a joint health and safety committee.

If a benzene control program is required, it must include engineering controls, work and hygiene practices, administrative controls and personal protective measures to reduce the exposure of workers to benzene.

Engineering Controls

Engineering controls can be grouped into the categories described in Chapter 4 of *A General Guide to the Regulations*. They include:

- material substitution
- process changes
- enclosure or isolation of emission sources

- local exhaust ventilation
- general ventilation.

Material Substitution

It may be possible to eliminate benzene from the workplace by replacing it with a less toxic material. This may be particularly true of solvent applications for benzene and in situations where it is possible to specify a non-benzene solvent or a solvent with a minimal benzene content. It is important, however, to carefully consider the toxicity and workplace hazard that may be imposed by the substitute material.

The replacement of benzene in solvent applications with substitutes such as toluene, xylene, and hexane, as well as low benzene-content naphthas, having benzene concentrations typically in the range 0.01 to 0.5 per cent, can lower worker exposure. The combination of benzene substitution with effective local exhaust ventilation has resulted in the reduction of benzene exposures to a TWA of less than 0.5 ppm.

Material Safety Data Sheets (MSDS) should be requested from solvent manufacturers or suppliers to obtain specific information on the benzene content of available solvent formulations. In this way decisions can be made on product substitutions to reduce benzene exposure in the workplace.

Process Changes

Various alternatives can be considered to reduce benzene exposure through changes in production or materials handling processes. Among these are:

- the use of closed systems for transfers of benzene
- bottom-loading of tank cars and trucks
- venting of tanks and storage vessels outside enclosed workplaces

- modification of loading arms and the installation of a totally sealed vacuum system in railcar loading
- double mechanical seals on pumps
- floating roof storage tanks with double seals
- closed loop sampling systems
- covering and sealing of sewer drains and sumps
- scrubber eductors or carbon filters on plant vents and stacks
- process unit leakage control around pumps, seals, flanges, valves, etc.
- isolation of sump skimming, pump out and draining operations.

Examples of ways in which various industrial sectors and plants have addressed the reduction of benzene exposure through process changes are discussed below.

Use of Vapour Leakage Control and Outside Vents

Adhesives are manufactured by batch processes in "kettles" that contain the solvent and to which the solid ingredients are added via a hopper-type feed. Many rubber adhesives require "mastication" of the rubber compound with the solvent in the kettle, using rapidly turning blades driven by powerful motors. This process generates a great deal of heat, causing volatilization of some of the solvent. These solvent vapours can be vented to the outside to alleviate worker exposure, and the use of effective seals around openings and pipe flanges can reduce fugitive emissions.

Closed Loop Sampling

Sampling of process streams and storage tanks for quality control purposes can result in a certain amount of exposure. Elimination of the need to flush sampling lines by the use of sample-loops, and of the need to gauge tanks manually by installation of remote level indicators will reduce exposure. In enclosed areas, control of emissions to the work environment is achieved by adsorption of vapour at vents and by ventilation.

Absorption, Adsorption and Condensation

Absorption, adsorption and condensation of hydrocarbons are important recovery techniques in the petrochemical industry. In absorption processes, benzene vapours are dissolved in a non-volatile solvent such as oil or furnace oil, which is subsequently steam stripped to recover the benzene. Benzene may also be recovered by condensing vapours in a water-cooled condenser. Adsorption involves the use of a granular solid medium such as activated carbon, which selectively attracts and retains benzene in the vapour stream for subsequent recovery by heating or steam stripping.

Venting to Flare Systems

Most petrochemical processes have pressure release vents, both as a protective measure and, in some cases, as a process control device. Sudden or unexpected upsets and scheduled shut-downs in process units can produce gas in excess of the capacity of the hydrocarbon recovery system. If the vent gas is flammable, as is the case for benzene, it may be routed to the flare system and burned. By venting to the flare, emissions to work areas can be avoided. In addition, the coupling of vents to the flare system enables vents to be set to operate at a lower pressure, thereby reducing pressure in process equipment and minimizing fugitive leaks from seals and gaskets.

Mechanical Pump Seals

One of the largest (and yet most difficult to control) categories of benzene emissions from refinery and petrochemical operations is fugitive emissions. The sources of such leaks are multiple, some of which, such as seals, gaskets and vents, have been mentioned already. Pumps and compressors required to move liquids and gases can leak products at the point of contact between the moving shaft and the stationary casing. Two types of seals commonly used in industry are packed seals and mechanical seals. The latter are more expensive but can reduce losses significantly, commonly by

90 per cent. In potential high hazard applications, such as the pumping of pure benzene, double seal construction is used, with provision made for venting the vapours that leak past the first seal.

Process Unit Leakage Control

Good process plant design provides for the immediate capture of accidental and, at times, inevitable, spills of benzene-containing liquids by means of spill trays and drip pans around pump seals and glands, the provision of berms and impoundments around storage tanks and by minimizing the number of flanges and interconnects where leakage can occur. Provision should also be made for conducting the spilled liquids to enclosed sumps and drains for subsequent treatment and disposal.

Floating Roof Storage Tanks

Benzene, gasoline and hydrocarbon solvents are stored in large volume facilities. The most frequently used type of storage tank is a vertical, cylindrical, fixed-roof vessel with a conical or domed roof. They are usually vented to the atmosphere and may represent a significant source of hydrocarbon losses. Uncontrolled storage tanks of this type can account for half of the gasoline emissions from a bulk terminal. These losses occur from evaporation and breathing of the tank during filling and emptying. The best technology for control of tankage losses consists of (1) floating a rigid cover on the surface of the stored liquid to reduce evaporation and eliminate the vapour space and (2) containing the tankage vapours within a sealed system that incorporates a variable vapour space to provide surge capacity. The efficiency of these approaches to controlling tank emissions is greater than 90 per cent when compared to uncontrolled tankage losses. Pure benzene is commonly stored in these floating-roof type facilities.

Loading Arm Modifications and Vapour Recovery

Benzene, volatile solvents and gasoline are distributed by pipeline, tanker trucks, railroad tank cars and marine tankers. Significant

vapour exposure can occur when the liquids are loaded into transport vehicles. Except for tanker trucks, the most common filling method is overhead loading. Worker exposure occurs because of vapour displacement as the tank is being filled through the open hatch and because visual monitoring of the liquid level is usually required. Various types of vapour collectors have been developed for use during overhead loading. They are essentially plug-shaped devices that are inserted into the hatch opening. The hydrocarbon flows through a central pipe in the device into the tank compartment. This pipe is surrounded by an annular space into which flow the displaced vapours. The annular space is, in turn, connected to a hose leading to a vapour disposal system. In Ontario such vapour recovery systems have been considered to be impractical because of the varied hatch geometrics that exist on transportation vehicles, and because of cost.

Fill lines used in benzene loading operations will contain benzene when the operation is terminated. Rather than allow this residual liquid to evaporate or to spill out of the lines it can be drained, either by gravity or by the application of suction, into a covered sump for subsequent recovery or disposal. Alternatively, benzene losses from line drainage following bulk transfers may be reduced by the application of "dry break flanges" on transfer line couplings. These couplings automatically attach a mechanical seal on the line as they are disconnected.

Bottom-Loading

Many gasoline tank trucks are fitted with bottom-loading capabilities. These facilities have loading arms with flexible tubes that connect to self-sealing valves on the side of the tank truck. Each filling tube has an automatic metering system, which is set by the driver/salesperson to prevent spill-over. The system is activated by a dead-man button located in an operator shack adjacent to the filling station. Some bottom-loading racks are also equipped with vapour recovery systems.

Enclosure/Isolation

Enclosure or isolation of benzene emission sources in the workplace can be accomplished through installation of enclosures around conveyor systems, driers and handling systems where solvent laden articles are being transferred, through isolation of solvent storage from the workplace and through the direction of benzene process vents and purges to storage or disposal. The maintenance of these enclosures at a slightly negative pressure through exhaust ventilation or vapour recovery collection systems will also serve to ensure that vapours do not escape into the workplace from the enclosure.

In some petrochemical plants and refiners the process control room is maintained at a slight positive pressure to reduce the entry of vapours from the outside plant. As the operators spend a considerable portion of their shift in the control room, worker exposure to benzene is thus minimized.

Solvent storage in enclosed areas of a process plant presents a potential for exposure to benzene vapours. Enclosure of such storage by a shed or room and the use of ventilation systems to direct vapours outside the building are effective means of reducing exposure to the benzene vapours.

Ventilation

In enclosed plants involved in fabrication processes using benzene and benzene-containing solvents, local ventilation at the point of emission can be used to reduce worker exposure.

Local exhaust ventilation must be provided at work stations and operations where methods of reducing benzene exposure to acceptable levels have proven to be inadequate.

Local exhaust ventilation hoods must be located as close to the source of benzene emissions as possible. Such ventilation would normally be applicable to work stations involving handling of

benzene or benzene-contaminated materials as a solvent, such as in laboratory analysis, around adhesive formulation kettles and at loading and unloading stations, on assembly line driers and rubber curing operations.

A good general workplace ventilation system is also important to dilute air contaminants and, indeed, may be the only ventilation necessary.

Regular maintenance of local exhaust and general ventilation systems should include checks for air leakage and condensation of benzene solvent vapours as well as routine checks of the fan and collector system. The location, height and dispersion of both local exhaust and general ventilation system outlets should be in accordance with the requirements of the Ministry of the Environment.

Standard practices in the design of industrial exhaust systems are described in reference texts such as *Industrial Ventilation, A Manual of Recommended Practice*, published by the American Conference of Governmental Industrial Hygienists.

Work Practices and Hygiene Practices

Inadvertent absorption of benzene into the body through swallowing, inhalation and skin contact can be avoided by diligent application of good hygiene and work practices. These practices should incorporate written procedures and plant rules addressing matters such as:

- consumption of food and drink at work stations
- personal cleanliness and hygiene
- equipment maintenance
- safety practices and emergency procedures
- housekeeping practices, spill prevention and clean-up
- smoking at work stations and personal hygiene associated with smoking.

The position of the operator during filling operations has an important influence on exposure, a factor that is particularly important in top-loading. Work procedures that require an operator to make only periodic visual checks on loading progress rather than to stand continuously on the loading platform reduce exposure. The use of a "dead-man" button remotely situated from the loading point, coupled with metering of liquid delivered, in bottom-loading facilities is an effective way of reducing exposure. Liquid levels in tank cars can be monitored by the use of probes that terminate loading operations at a pre-set level or by the use of magnetic gauges that give the loader a remote visual check of the level.

The use of metering pumps, level indicators and dead-man buttons to control loading operations also reduces the danger of fire from overfilling.

Administrative Controls

As noted in *A General Guide to the Regulations*, administrative controls relate primarily to personnel practices and management strategies that can reduce the exposure of individual workers to benzene. They may include:

- the scheduling of maintenance, equipment replacement, pump repair or other operations with potential for high benzene exposure for periods when few workers are present;
- the rotation of work schedules to limit the time that any worker is exposed to benzene; and
- the establishment of work-rest schedules that limit the duration of worker exposure to benzene at an individual work station.

Personal Protective Equipment

The use of personal protective equipment should be regarded as a supplementary measure to engineering controls and other procedures for controlling emissions of benzene into the workplace.

Personal protective equipment includes protective gloves, clothing, footwear, face and eye shields and respirators. The type of protection selected must be appropriate to the job site in question, be compatible with prevention of exposure to or contact with benzene and take into consideration worker comfort and potential for causing heat stress.

In situations where local exhaust ventilation or general ventilation is effective in reducing airborne levels of benzene, but the potential for skin contact remains, gloves and footwear that provide an acceptable barrier to benzene penetration should be worn together with work clothing that is removed at the end of the work shift.

When it is necessary that respirators be worn they must be supplied by the employer, and the employer must provide training and instruction to the worker in the proper care and use of the respirator.

The Type of Respirator Required

The type of respirator should be appropriate for the level of airborne benzene that is of concern. Use of respirators should conform to the practices outlined in Chapter 5 of *A General Guide to the Regulations*.

The type of respirator required for various levels of airborne benzene and the general requirements for the use of respirators are detailed in the *Code for Respiratory Equipment for Benzene*, dated June 30, 2000, and appended to the regulation. Respirators must meet or exceed the following requirements:

Concentration of Airborne Benzene	Type of Respirator Required
Less than or equal to 10 ppm	Air-purifying half mask respirator equipped with organic vapour cartridges.
Greater than 25 ppm	Powered air-purifying respirator with a loose fitting hood or helmet, or supplied air respirator equipped with a hood or helmet and operated in continuous flow mode (see note 1).

Notes:

1. Respirators with higher protection factors or required for protection from higher airborne benzene concentrations must be selected in accordance with the NIOSH assigned protection factors as given in Table 2 of its publication entitled *NIOSH Respirator Decision Logic* dated May 1987; and respirators for escape must be selected in accordance with Table 4 of this NIOSH publication.

2. Since the odour threshold is 5 ppm or higher, the organic vapour cartridges must be replaced at the beginning of each work shift or after 8 hours use.

3. Respirators need not be worn if the time-weighted average exposure of a worker is less than 1.0 ppm. However, if a worker wishes to use a respirator, the correct type of respirator must be worn.

4. Measuring Airborne Benzene

Chapter 6 of *A General Guide to the Regulations* describes the reasons for the measurement of airborne concentrations of benzene in the workplace, the purposes for which these measurements are applied and how to calculate the time-weighted average exposure of a worker.

Compliance with the regulation requires the use of procedures that are in accordance with standard methods for workplace air sampling and analysis, i.e., methods published by agencies such as NIOSH (the U.S. National Institute for Occupational Safety and Health), OSHA (U.S. Occupational Safety and Health Administration), HSE (U.K. Health and Safety Executive), ASTM (American Society for Testing and Materials) and ISO (International Organization for Standardization).

5. Medical Surveillance for Exposure to Benzene

The benzene regulation requires that the control program provide for a medical surveillance program, which must include:

- pre-employment, pre-placement and periodic medical examinations
- clinical tests
- health education
- record keeping.

The requirements are detailed in the *Code for Medical Surveillance of Benzene Exposed Workers*, dated October 29, 1984 and appended to the benzene regulation.

The medical surveillance program is designed to protect the health of workers through the detection of any adverse health effects due to benzene exposure and by the education of all staff on the health hazards associated with benzene exposure.

Section 3 of the Code explains what the physician should look for at the pre-placement and periodic medical examinations. Medical records kept by the physician should include the information listed in section 6 of the Code. This program is to be undertaken at the employer's expense.

A detailed outline of the general requirements for medical surveillance is contained in Chapter 7 of *A General Guide to the Regulations*.

Clinical Tests

Section 4 of the Code explains the clinical tests that are used in assessing the worker's benzene exposure and fitness for continued exposure to benzene. These include hematological (blood) tests, which are designed to reveal blood cell abnormalities that may be attributable to benzene exposure. Notwithstanding the results of these tests, a benzene-exposed worker must be removed from exposure if any other symptoms or signs of benzene toxicity are present.

The Examining Physician

The benzene regulation does not stipulate who shall be the examining physician, thus allowing the worker to select the doctor of his or her choice. As a result, the examining physician may be the company doctor, a private consultant with whom the employer contracts services, a physician on the staff of a clinic or the personal physician of the worker. Every examining physician must know the content of the *Code for Medical Surveillance of Benzene Exposed Workers* and his or her responsibilities. Where there is more than one examining physician, a physician should be appointed in a co-ordinating role. The role of the co-ordinating physician, who should be selected jointly by the employer and the joint health and safety committee, should be to standardize examination and test procedures, maintain medical records and identify any trends in examination and test results.

Physicians' Reporting Protocol

The regulation requires the examining physician to advise the employer whether the worker is fit, fit with limitations or unfit for exposure to benzene. This determination is a professional judgement based on the results of medical examinations and clinical tests. **The physician must give this opinion without disclosing to the employer the results of the examinations or tests.**

The regulation requires the physician to advise the joint health and safety committee in writing of the results of clinical tests, along with an opinion as to how these tests should be interpreted and an opinion as to the fitness of the worker for exposure. In all such cases, the committee must receive this information on a confidential basis. If the physician has advised the employer that a worker is fit with limitations or unfit, he or she must also report this information to the Ministry of Labour's Provincial Physician. These requirements are specified in sections 16(1), 16(2), 16(3) and 16(5) of the regulation.

6. Appendices

Appendix 1 - Regulations made under the *Occupational Health and Safety Act* Revised Statutes of Ontario, 1990, Chapter O.1 as amended

February 1, 2001

A. Safety Regulations

Construction Projects:	O. Reg. 213/91, as amended by O. Reg. 631/94, O. Reg. 143/99, O. Reg. 571/99, O. Reg. 145/00, and O. Reg. 527/00.
Industrial Establishments:	R.R.O. 1990, Reg. 851, as amended by O. Reg. 516/92, O. Reg. 630/94, O. Reg. 230/95, O. Reg. 450/97, O. Reg. 144/99, O. Reg. 284/99, and O. Reg. 528/00.
Mines and Mining Plants:	R.R.O. 1990, Reg. 854, as amended by O. Reg. 583/91, O. Reg. 584/91, O. Reg. 171/92, O. Reg. 384/92, O. Reg. 571/92, O. Reg. 693/92, O. Reg. 60/94, O. Reg. 779/94, O. Reg. 68/96, O. Reg. 272/97, O. Reg. 236/99 and O. Reg. 486/99.
Window Cleaning:	R.R.O. 1990, Reg. 859, as amended by O. Reg. 523/92.
Critical Injury Defined:	R.R.O. 1990, Reg. 834.
Training Requirements for Certain Skill Sets and Trades:	O. Reg. 572/99.
Diving Operations:	O. Reg. 629/94.
Firefighters—Protective Equipment:	O. Reg. 714/94, as amended by O. Reg. 449/97.
Health Care and Residential Facilities:	O. Reg. 67/93 as amended by O. Reg. 142/99.
Oil and Gas—Offshore:	R.R.O. 1990, Reg. 855.
Roll-Over Protective Structures:	R.R.O. 1990, Reg. 856.
Teachers:	R.R.O. 1990, Reg. 857.
University Academics and Teaching Assistants:	R.R.O. 1990, Reg. 858.

B. Designated Substances

Acrylonitrile:	R.R.O. 1990, Reg. 835, as amended by O. Reg. 507/92.
Arsenic:	R.R.O. 1990, Reg. 836, as amended by O. Reg. 508/92.

Asbestos:	R.R.O. 1990, Reg. 837, as amended by O. Reg. 509/92, O. Reg. 598/94 and O. Reg. 386/00.
Asbestos on Construction Projects and in Buildings and Repair Operations:	R.R.O. 1990, Reg. 838, as amended by O. Reg. 510/92.
Benzene:	R.R.O. 1990, Reg. 839, as amended by O. Reg. 511/92 and O. Reg. 387/00.
Coke Oven Emissions:	R.R.O. 1990, Reg. 840, as amended by O. Reg. 512/92.
Ethylene Oxide:	R.R.O. 1990, Reg. 841, as amended by O. Reg. 515/92.
Isocyanates:	R.R.O. 1990, Reg. 842, as amended by O. Reg. 518/92.
Lead:	R.R.O. 1990, Reg. 843, as amended by O. Reg. 519/92 and O. Reg. 389/00.
Mercury:	R.R.O. 1990, Reg. 844, as amended by O. Reg. 520/92 and O. Reg. 390/00.
Silica:	R.R.O. 1990, Reg. 845, as amended by O. Reg. 521/92 and O. Reg. 391/00.
Vinyl Chloride:	R.R.O. 1990, Reg. 846, as amended by O. Reg. 522/92 and O. Reg. 392/00.

C. General

Biological or Chemical Agents, Control of Exposure to:	R.R.O. 1990, Reg. 833, as amended by O. Reg. 513/92, O. Reg. 597/94 and O. Reg. 388/00.
Hazardous Materials Inventories:	R.R.O. 1990, Reg. 850, revoked by O. Reg. 397/93.
Workplace Hazardous Materials Information System:	R.R.O. 1990, Reg. 860, as amended by O. Reg. 36/93.

D. Hazardous Physical Agents

X-Ray Safety:	R.R.O. 1990, Reg. 861.

E. Regulations that Directly Affect/Impact the Act

Training Programs:	O. Reg. 780/94.
Unilateral Work Stoppage:	O. Reg. 243/95.
Inventory of Agents or Combinations of Agents for the Purpose of Section 34 of the Act:	R.R.O. 1990, Reg. 852, as amended by O. Reg. 517/92.
Joint Health and Safety Committees—Exemption from Requirements:	O. Reg. 385/96, as amended by O. Reg. 131/98.

NOTE:

For a complete reference to the Regulations made under the *Occupational Health and Safety Act*, please see the Annual Consolidated Index to the Regulations of Ontario.

Appendix 2 - Ministry of Labour Field Offices

CENTRAL REGION

Toronto North
1201 Wilson Ave
West Bldg, 2nd Fl
Downsview M3M 1J8
(416) 235-5330
Fax (416) 235-5080

Toronto West
1201 Wilson Ave
West Bldg, 2nd Fl
Downsview M3M 1J8
(416) 235-5330
Fax (416) 235-5090

Peel North
The Kaneff Centre, 1st Fl
1290 Central Pkwy West
Mississauga L5C 4R3
(905) 273-7800
*1-800-268-2966
Fax (905) 615-7098

Peel South
The Kaneff Centre, 1st Fl
1290 Central Pkwy West
Mississauga L5C 4R3
(905) 273-7800
*1-800-268-2966
Fax (905) 615-7098

Toronto East
2275 Midland Ave, Main Fl
Scarborough M1P 3E7
(416) 314-5300
Fax (416) 314-5410

Durham
209 Dundas St E, Ste 204
Whitby L1N 7H8
(905) 665-4979
*1-800-263-1195
Fax (905) 665-4983

Barrie
114 Worsley St, Ste 201
L4M 1M1
(705) 722-6642
*1-800-461-4383
Fax (705) 726-3101

York
1110 Stellar Drive, Unit 102
Newmarket L3Y 7B7
(905) 715-7020
*1-888-299-3138
Fax (905) 715-7140

EASTERN REGION

Ottawa West
1111 Prince of Wales Dr,
Ste 200
K2C 3T2
(613) 228-8050
*1-800-267-1916
Fax (613) 727-2900

Ottawa East
1111 Prince of Wales Dr,
Ste 200
K2C 3T2
(613) 228-8050
*1-800-267-1916
Fax (613) 727-2900

Kingston
Beechgrove Complex
51 Heakes Lane
K7M 9B1
(613) 545-0989
*1-800-267-0915
Fax (613) 545-9831

Peterborough
Robinson Place (MNR Bldg.)
300 Water St N
3rd Fl South Tower
K9J 8M5
(705) 755-4700
*1-800-461-1425
Fax (705) 755-4724

NORTHERN REGION

Sudbury West
159 Cedar St, Ste 301
P3E 6A5
(705) 564-7400
*1-800-461-6325
Fax (705) 564-7435

Sudbury East
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P3E 6A5
(705) 564-7400
*1-800-461-6325
Fax (705) 564-7435

Sault Ste. Marie
70 Foster Dr, Ste 480
P6A 6V4
(705) 945-6600
*1-800-461-7268
Fax (705) 949-9796

Elliot Lake
50 Hillside Dr N
P5A 1X4
*1-800-461-7268
Fax (705) 848-8055

Thunder Bay
435 James St S, Ste 222
P7E 6S7
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*1-800-465-5016
Fax (807) 475-1646

Dryden
479 Government Rd
P8N 3B3
(807) 223-4898
*1-800-465-5016
Fax (807) 223-4344

Timmins
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South Porcupine P0N 1H0

(office address)
Ontario Government Complex
D Wing
Highway 101 E
Porcupine P0N 1C0
(705) 235-1900
*1-800-461-9847
Fax (705) 235-1925

Kapuskasing
c/o MNR
RR #2, Hwy 17 W
P5N 2X8
(705) 235-1900
*1-800-461-9847
Fax (705) 335-8330

North Bay
447 McKeown Ave, 2nd Fl
P1B 9S9
*1-800-461-6325
Fax (705) 497-6850

WESTERN REGION

Hamilton
1 Jarvis St, Main Fl
L8R 3J2
(905) 577-6221
*1-800-263-6906
Fax (905) 577-1200

Brant
1 Jarvis St, Main Fl
Hamilton L8R 3J2
(905) 577-6221
*1-800-263-6906
Fax (905) 577-1324

Halton
1 Jarvis St, Main Fl
Hamilton L8R 3J2
(905) 577-6221
*1-800-263-6906
Fax (905) 577-1324

Niagara
301 St. Paul St, 8th Fl
St. Catharines L2R 7R4
(905) 704-3994
*1-800-263-7260
Fax (905) 704-3011

London North
217 York St, 5th Fl
N6A 5P9
(519) 439-2210
*1-800-265-1676
Fax (519) 672-0268

London South
217 York St, 5th Fl
N6A 5P9
(519) 439-2210
*1-800-265-1676
Fax (519) 672-0268

Kitchener
155 Frobisher Dr, Unit G213
Waterloo N2V 2E1
(519) 885-3378
*1-800-265-2468
Fax (519) 883-5694

Windsor
250 Windsor Ave, Ste 635
N9A 6V9
(519) 256-8277
*1-800-265-5140
Fax (519) 258-1321

MAIN OFFICE

Toronto
400 University Ave, 7th Fl
M7A 1T7

Occupational Health and Safety Branch - (416) 326-7770

Construction Health and Safety Program - (416) 326-2439

Industrial Health and Safety Program - (416) 326-2445

Professional and Specialized Services - (416) 326-2443

Fax (416) 326-7761

Mining Health and Safety Program
Willet Green Miller Centre
Building B
933 Ramsey Lake Rd
Sudbury P3E 6B5
(705) 670-5695
Fax (705) 670-5698

Material Testing Laboratory
Willet Green Miller Centre
Building C
933 Ramsey Lake Road
Sudbury P3E 6B5
(705) 670-5695
Fax (705) 670-5698

Radiation Protection Service
81A Resources Rd
Weston M9P 3T1
(416) 235-5922
Fax (416) 235-5926

Publications
400 University Ave, 7th Fl
Toronto M7A 1T7
(416) 326-7731
*1-800-268-8013 ext 6-7731
[province-wide]
Fax (416) 326-7745

* Toll-Free Number [Note: Many of these "1-800" numbers are accessible only within the area code of the relevant office.]

For inquiries please contact the Ministry of Labour office nearest to you. Consult the blue pages in your local telephone directory for additional information.

Notes